

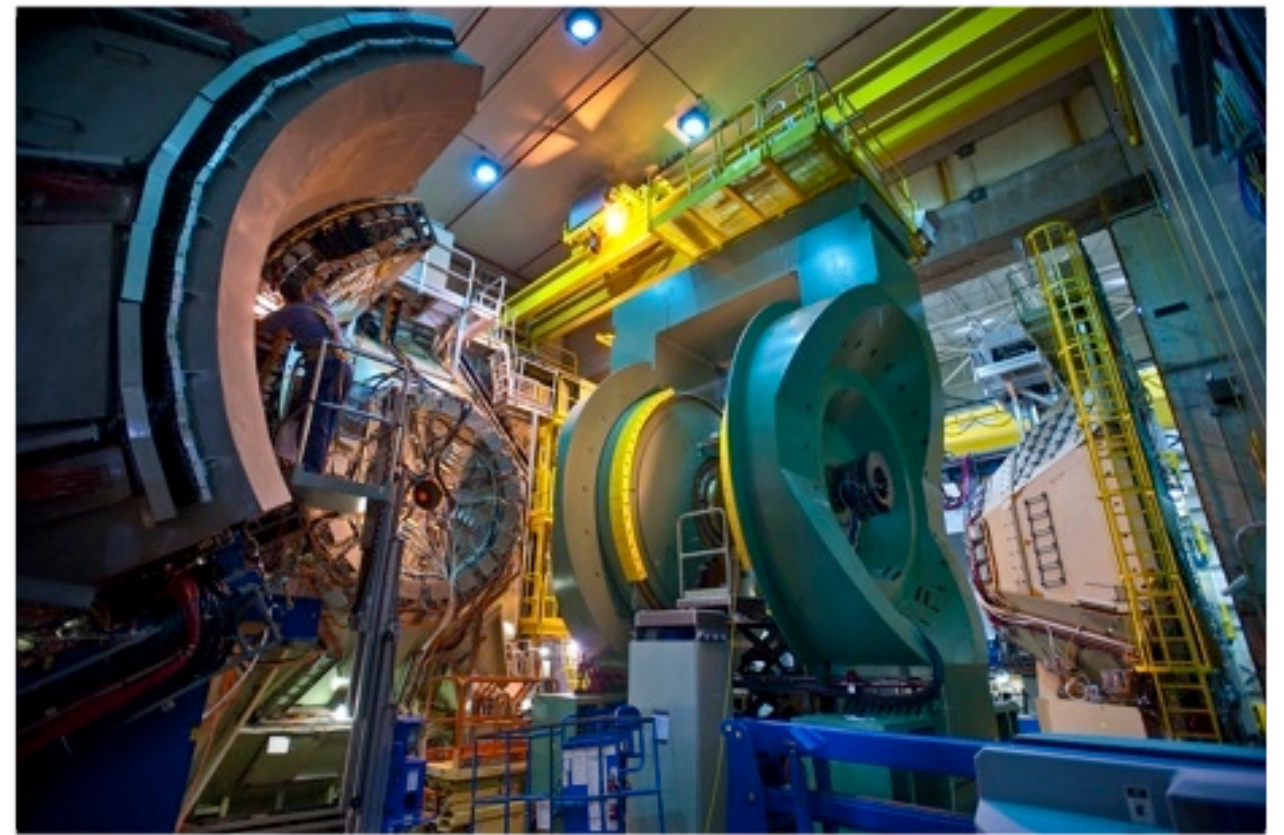
W Boson Measurements at PHENIX

Hideyuki Oide (University of Tokyo / RIKEN)

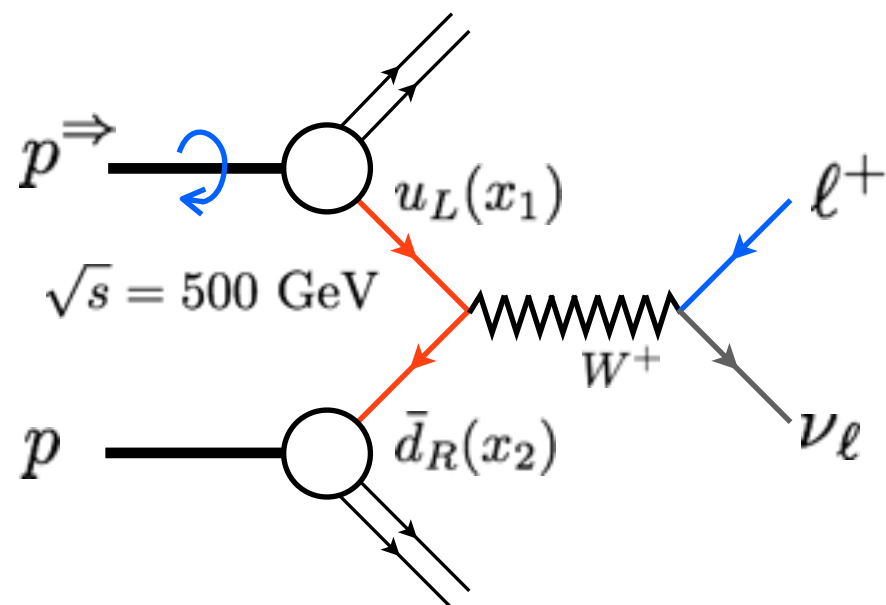
on behalf of PHENIX collaboration

Outline

- Probing sea quark polarization via weak boson
- PHENIX Forward Upgrade Project
- Run9 $W \rightarrow e$ result & Run11 $W \rightarrow e$ status
- Run11 $W \rightarrow \mu$ analysis: preliminary result
- Run12+ prospect



Probing sea quark polarization via $W^\pm \rightarrow \ell^\pm$

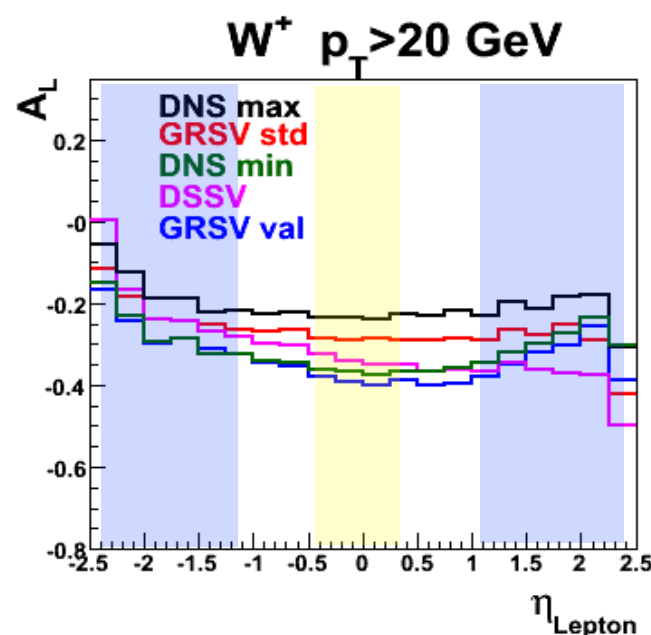
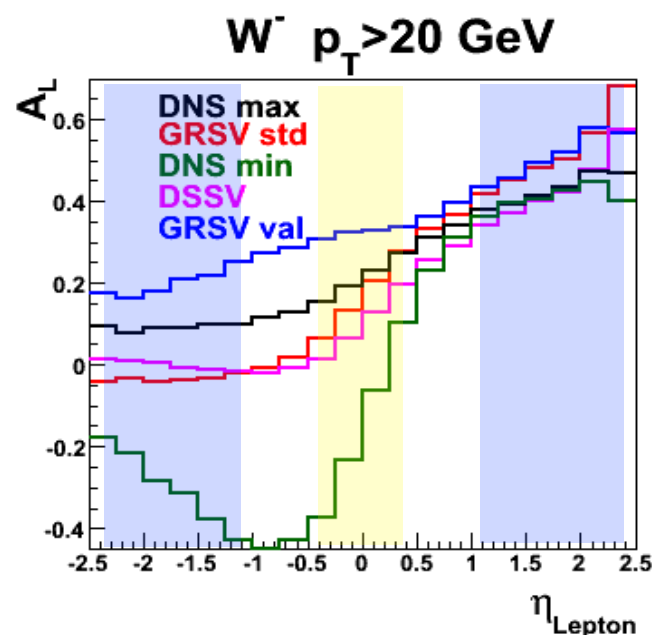


$$d\sigma(p^{\Rightarrow} p \rightarrow W^+) \propto u_L^{\Rightarrow}(x_1)\bar{d}_R(x_2) + \bar{d}_R^{\Rightarrow}(x_1)u_L(x_2)$$

Single Spin Asymmetry via parity violating weak coupling.

$$A_L = \frac{d\sigma^{\Rightarrow} - d\sigma^{\Leftarrow}}{d\sigma^{\Rightarrow} + d\sigma^{\Leftarrow}}$$

Sensitive to flavor-selecting sea quark polarization.



PHENIX : suitable for **leptonic decays**

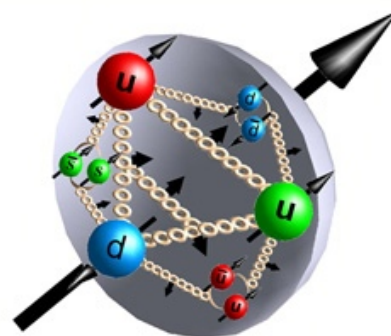
- Central Arm: $W^\pm \rightarrow e^\pm$
- Forward Muon Arms: $W^\pm \rightarrow \mu^\pm$

via measuring single lepton's pT and rapidity

Wide range rapidity region covered.

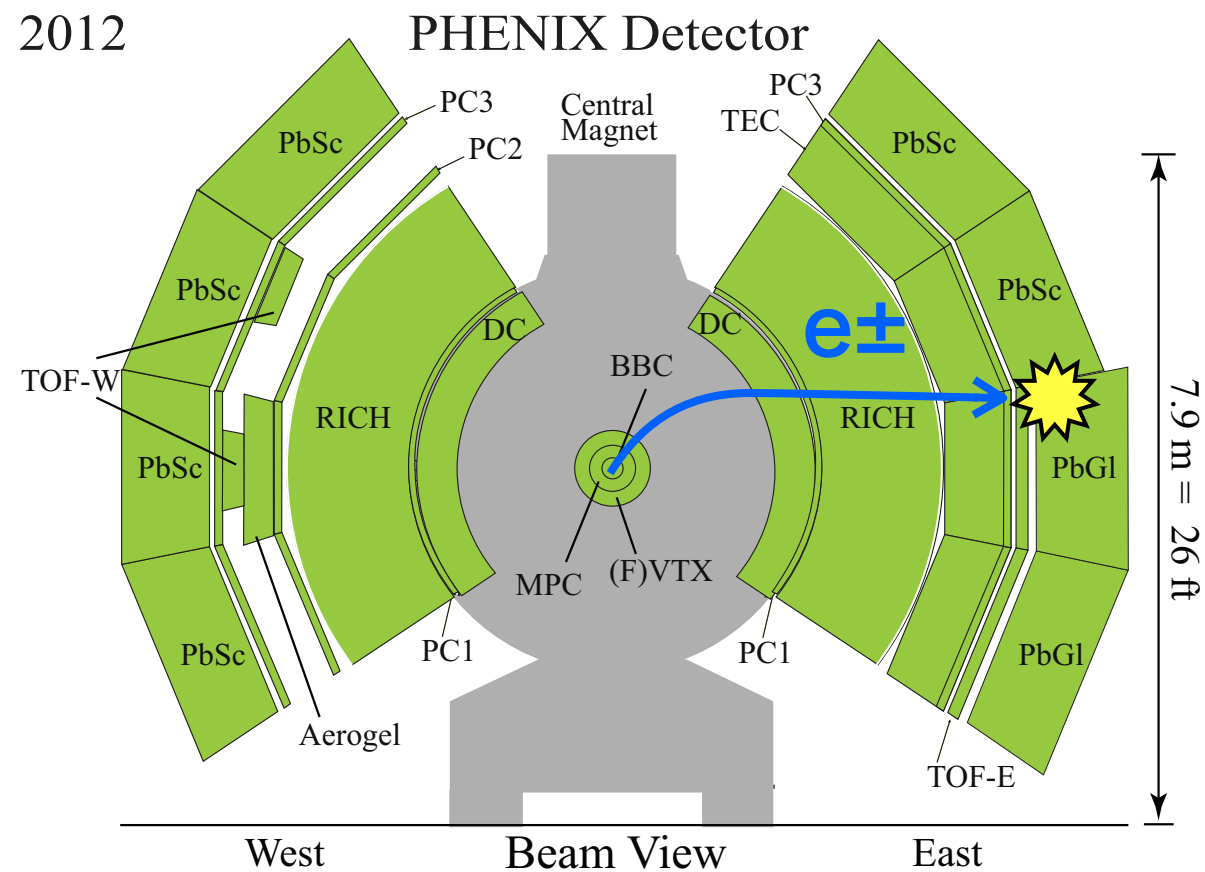
(e.g. \bar{d} polarization is seen at large negative rapidity in $W^- \rightarrow \ell^-$)

One of the key measurements to the “Spin Puzzle”



Measurement of W in PHENIX

2012

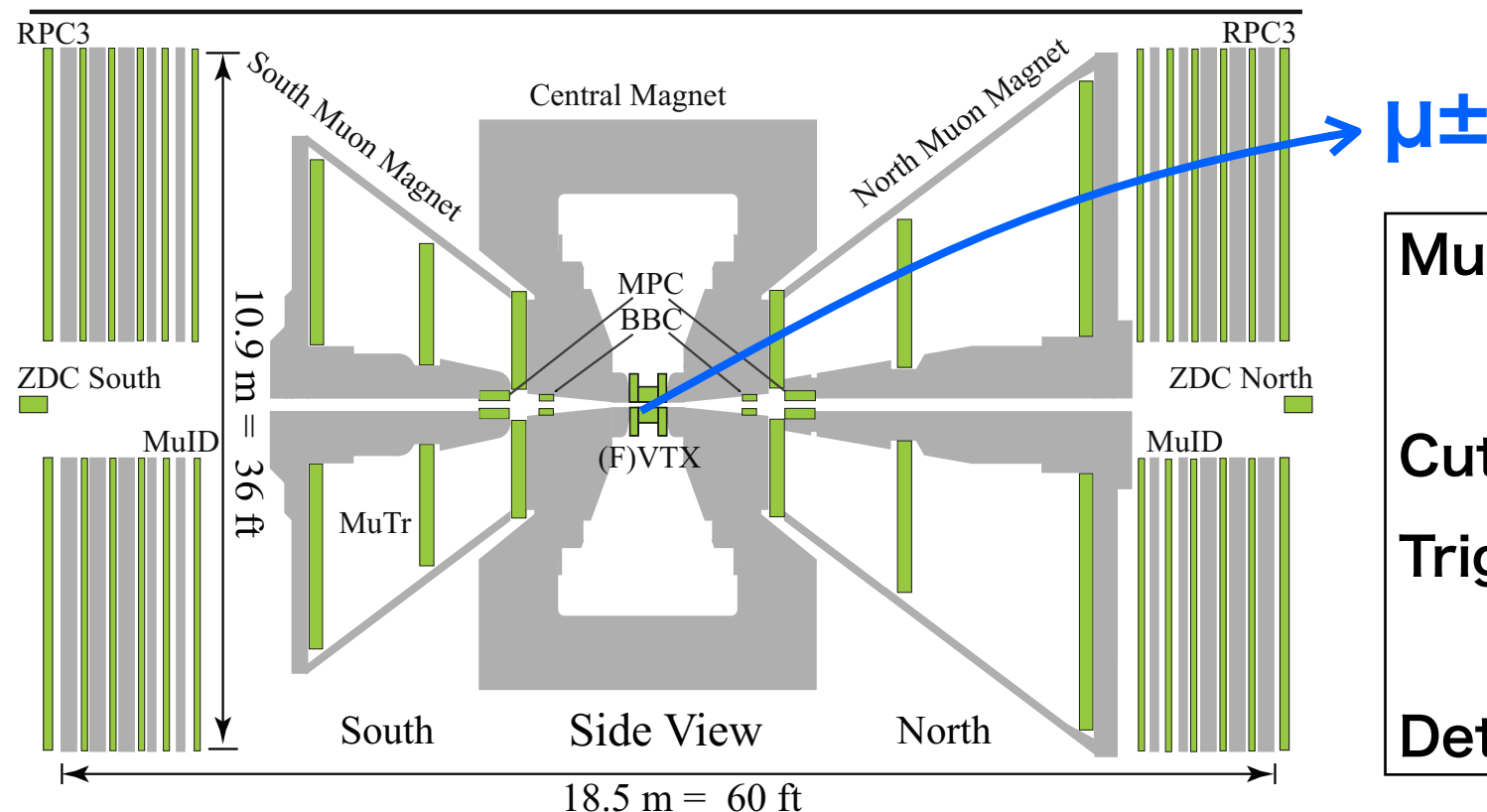


Central Arm: $|\eta| < 0.35$

**Cut: isolated single electron
at Jacobian peak**

Trigger: EMCal + RICH ("ERT")

Detectors: DC, PC, EMCal



Muon Arm: $-2.2 < \eta < -1.2$ (South)

$1.2 < \eta < 2.4$ (North)

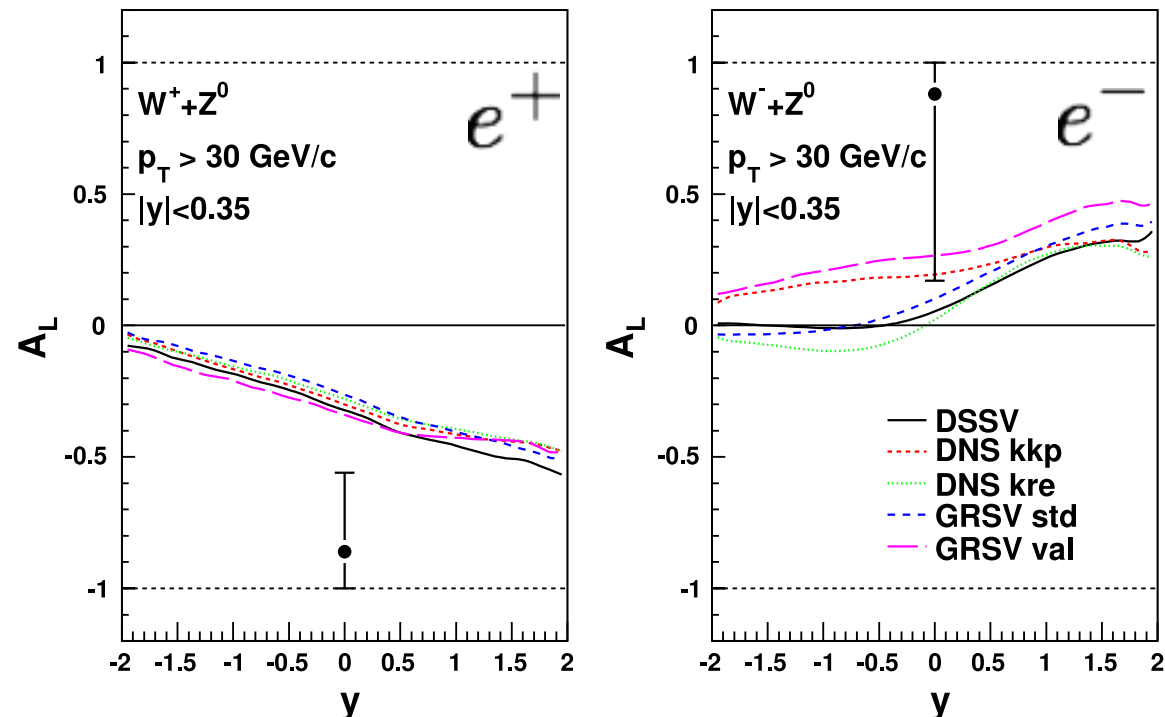
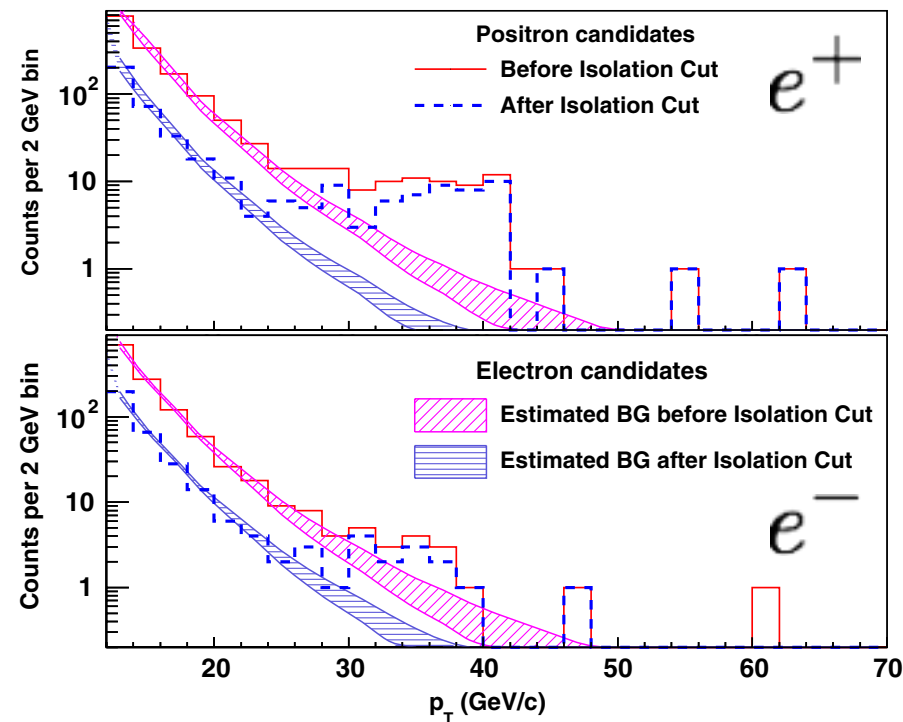
Cut: well-qualified single muon

**Trigger: Small sagitta + MuID
+ timing (RPC/BBC)**

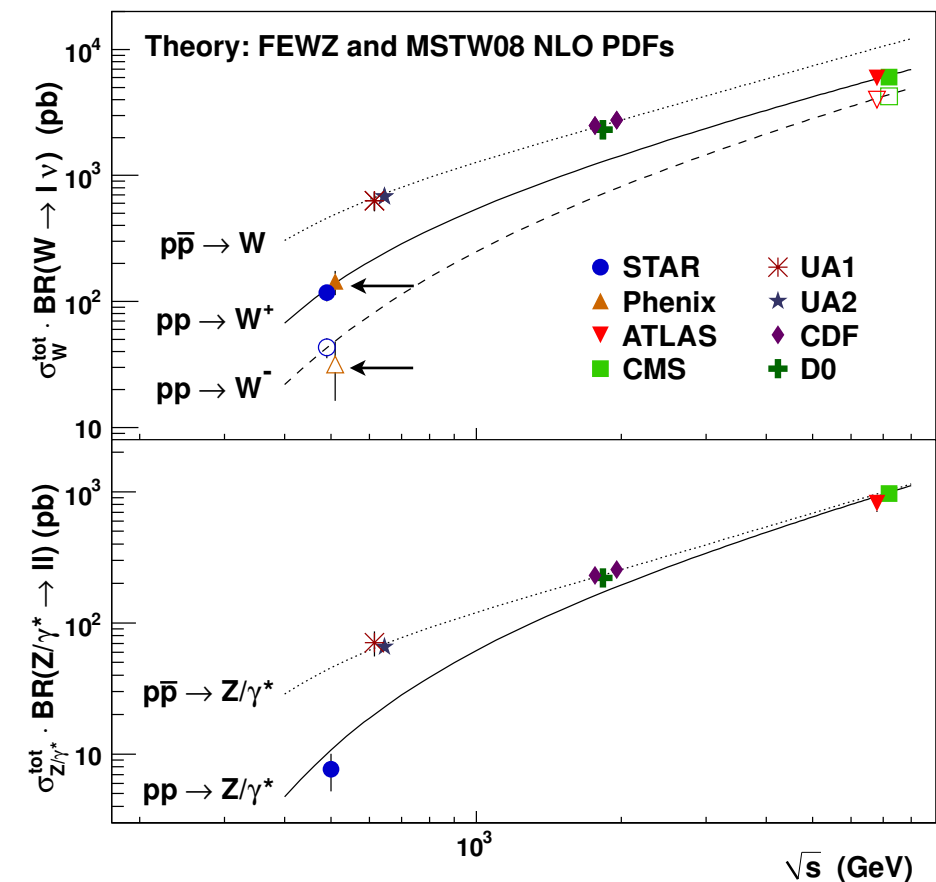
Detectors: MuTr, MuID, RPC, BBC

Run9 $W \rightarrow e$ Result in Central Arm

Run9 $\sqrt{s} = 500$ GeV integrated luminosity: 8.6 pb^{-1} in $|\text{vtxz}| < 30$ cm (ERT 4x4b trigger)



PHENIX Collaboration PRL106.062001

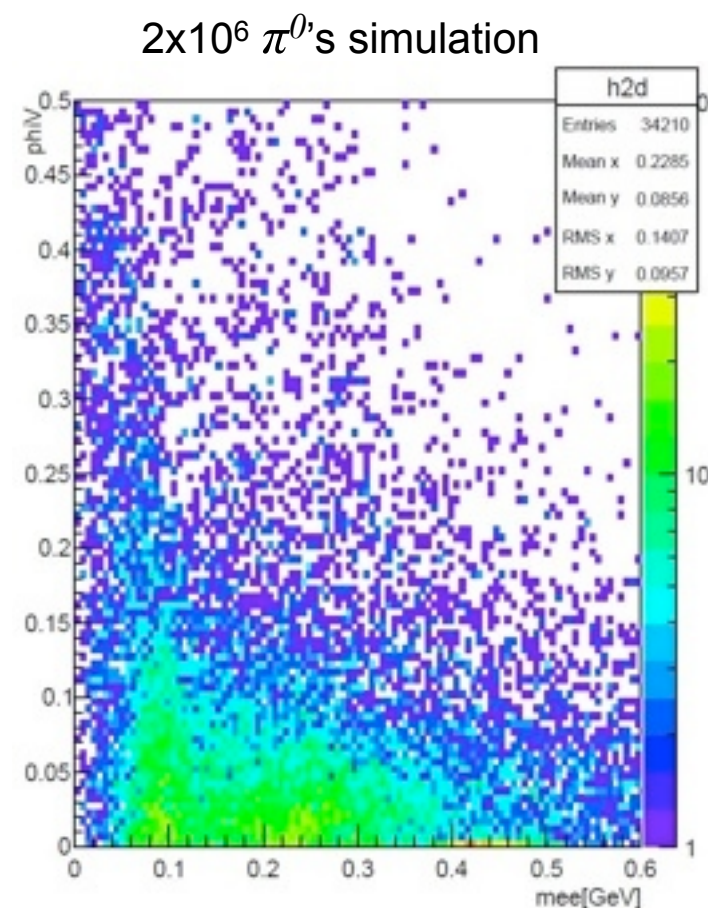
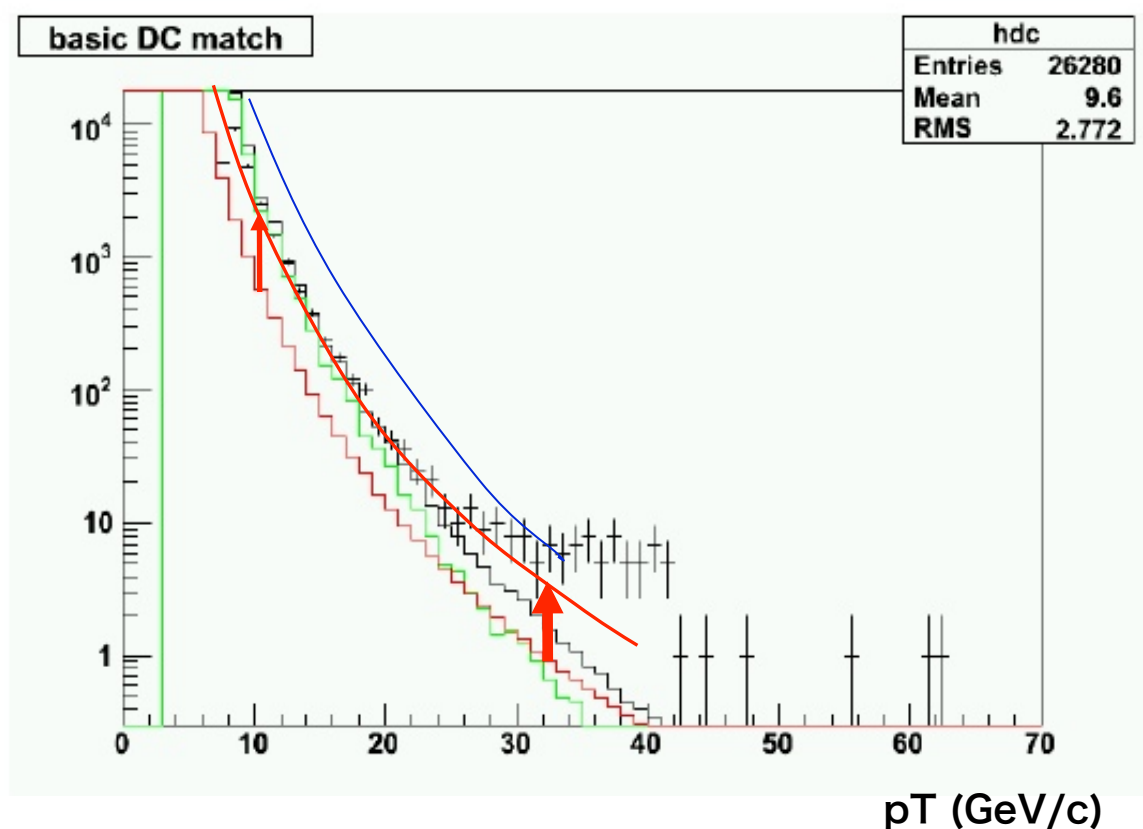


STAR Collaboration [arXiv:1112.2980v1](https://arxiv.org/abs/1112.2980v1)

Single Spin Asymmetry Result ($p_T > 30$ GeV/c)

$$\begin{aligned}
 W^+ + Z^0 &: -0.86 \quad [-1, -0.56] \\
 W^- + Z^0 &: +0.88 \quad [+0.17, +1] \\
 ([] &: 68\% \text{C.L.})
 \end{aligned}$$

Run11 Central Arm Analysis Status



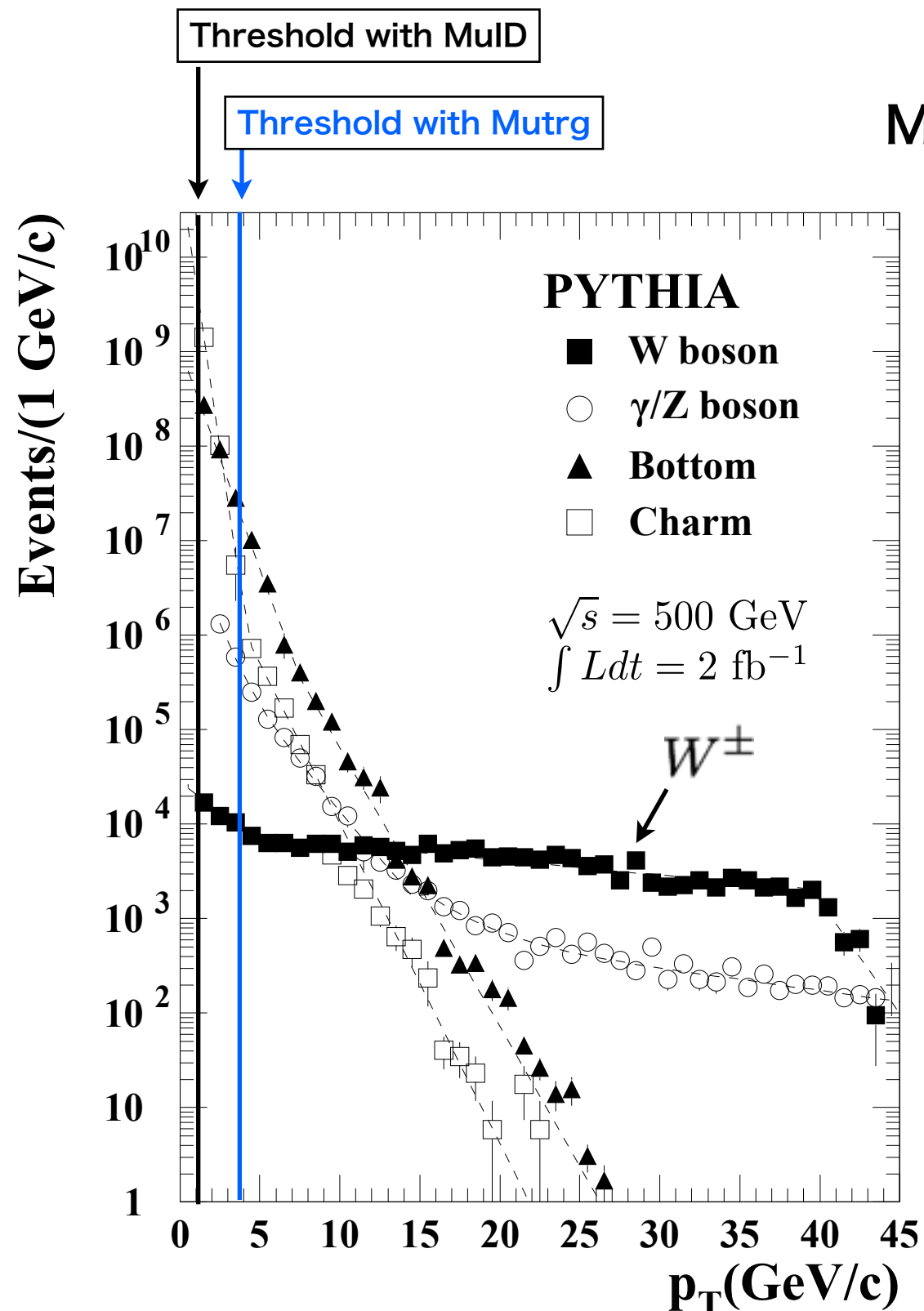
The newly installed central VTX detector has a larger X_0 than previously installed HBD, more of e^\pm pairs from π^0 photons appear (photon conversion).

==> factor ~3 photon conversion increase compared to Run9.

- Simulation studies to identify the sources of conversion is underway.
- Data analysis is in progress.

The result will come out soon!

Forward Muon Trigger Upgrade



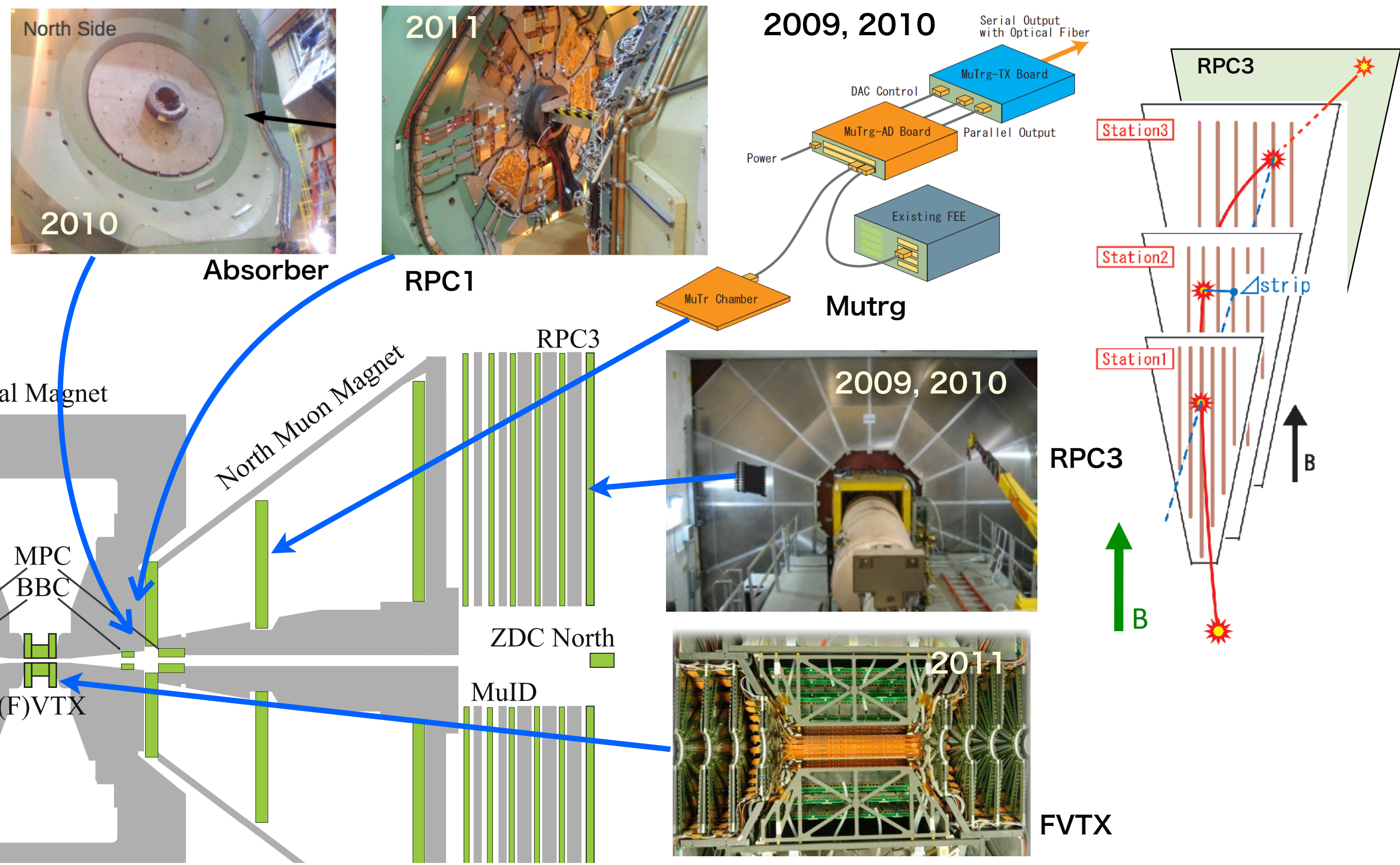
Motivation of PHENIX forward upgrade project:

Due to limited trigger bandwidth, the original muon trigger “MuID” is short to acquire all W collisions without pre-scaling.
==> Needs a **high momentum trigger**.

[Strategy]

1. Discriminates muon momentum using **sagitta**
(Mutrg: parasitic trigger electronics inside MuTr + RPC)
==> Trigger **$p_T > 4 \text{ GeV}/c$**
2. For ID of spin pattern / bunch crossing at high collision rate, beam beam counter (BBC) is not tolerable.
==> Introduce resistive plate chambers (**RPC**)
3. Introduce additional hadron absorbers to reject hadronic backgrounds.
4. FVTX detector will work for increasing analysis power.

PHENIX Forward Upgrade Program

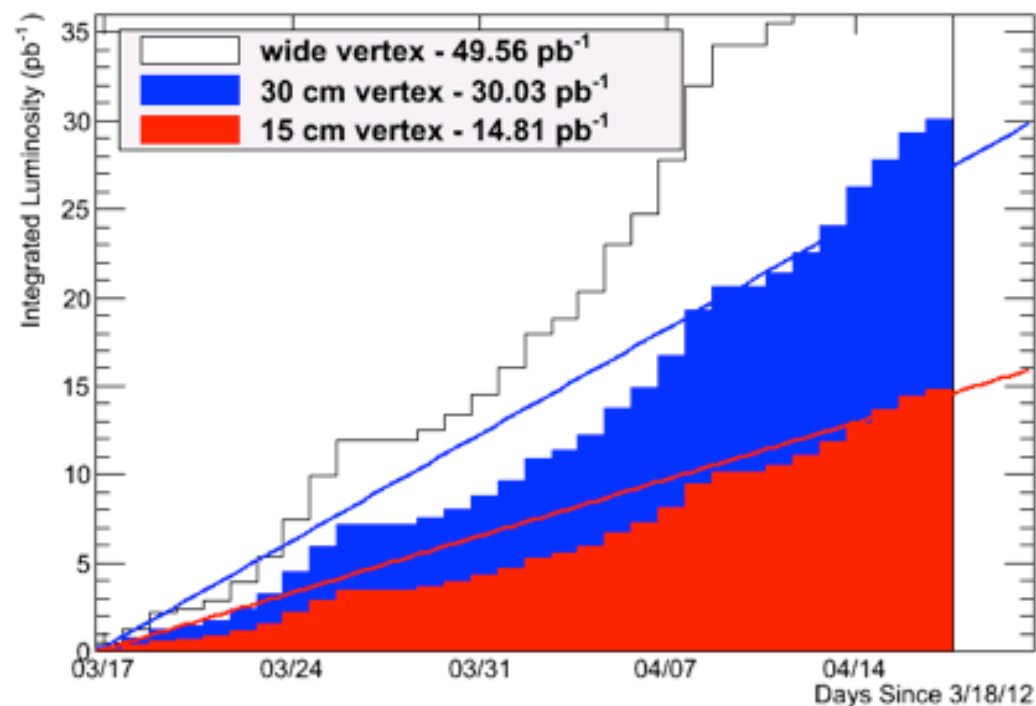


Upgrade History

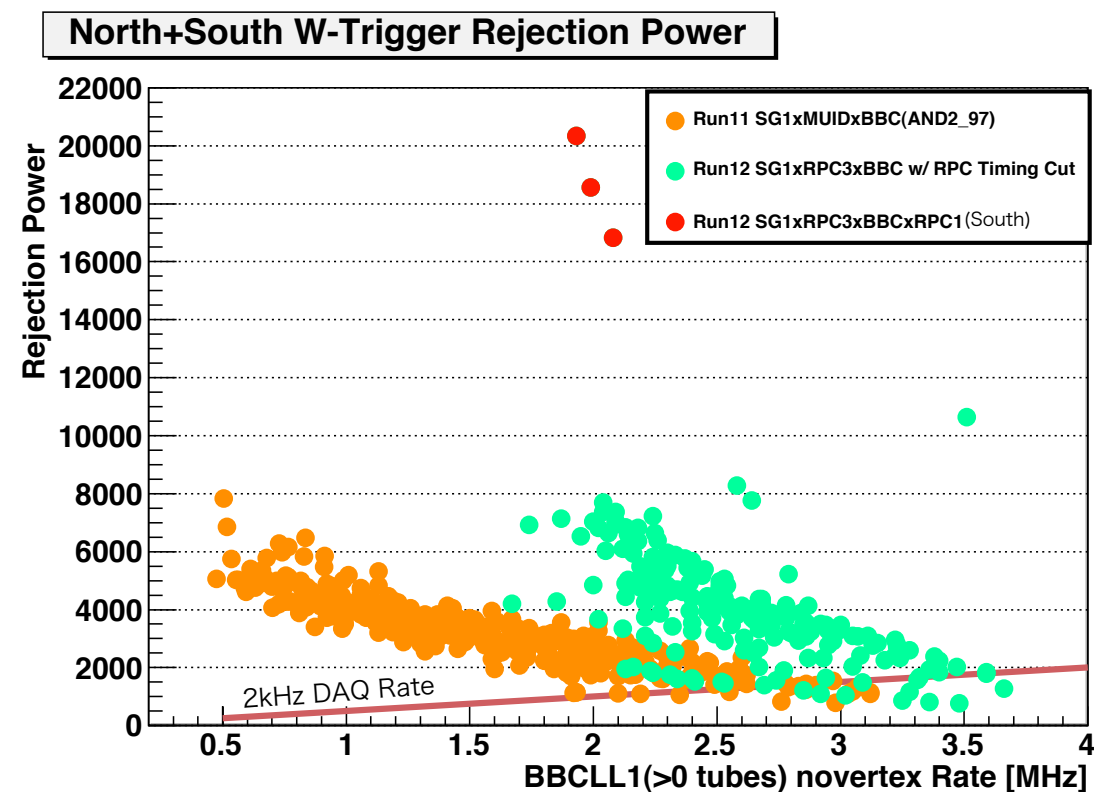
Year			2009		2010		2011		2012	
Run Status			pp Run	-	-		pp Run	-	pp Run	-
FWD	MuTrg		install/commissioning				operation / Physics Trigger			
	RPC3	S				install	operation		operation / Physics Trigger	
		N		install	commissioning					
	RPC1							install	comm./operation	
	FVTX							install	comm./operation	
CNT	HBD		operation	removed						
	VTX					install	comm.	operation		
W->mu TRG			(MuIDxBBC -- prescaled)				SG1xMuIDxBBC		SG1xRPC3xBBC	
Luminosity vtx < 30 cm			8.6		-		16		30	
√s			500		-		500		510	

Run12 Muon Arm performances

Run12 $\sqrt{s} = 510$ GeV luminosity history



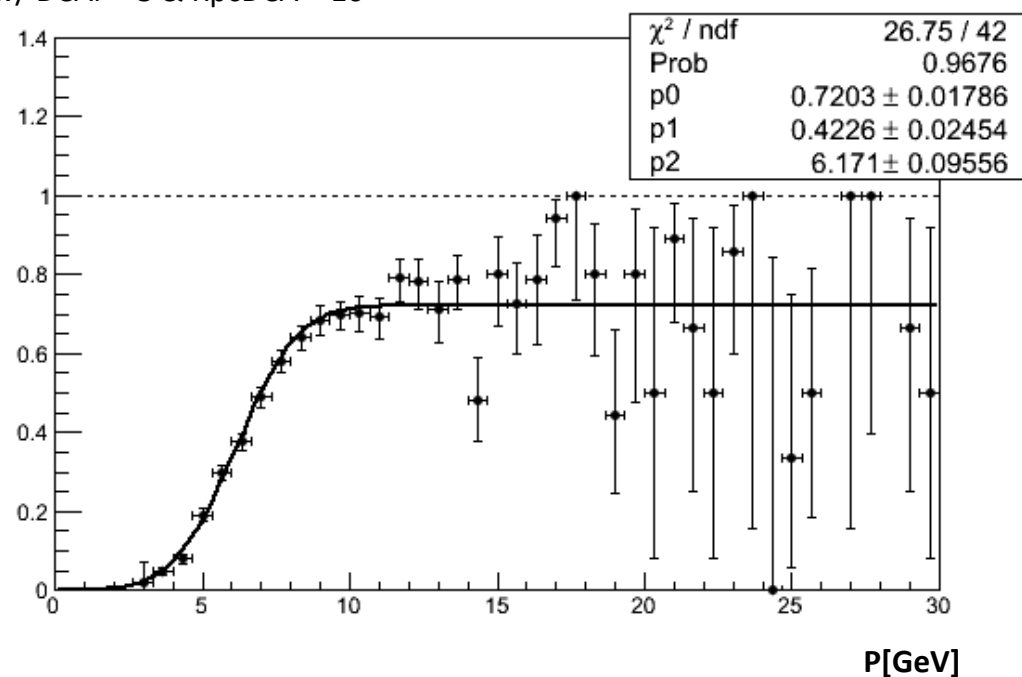
Trigger Rejection Power



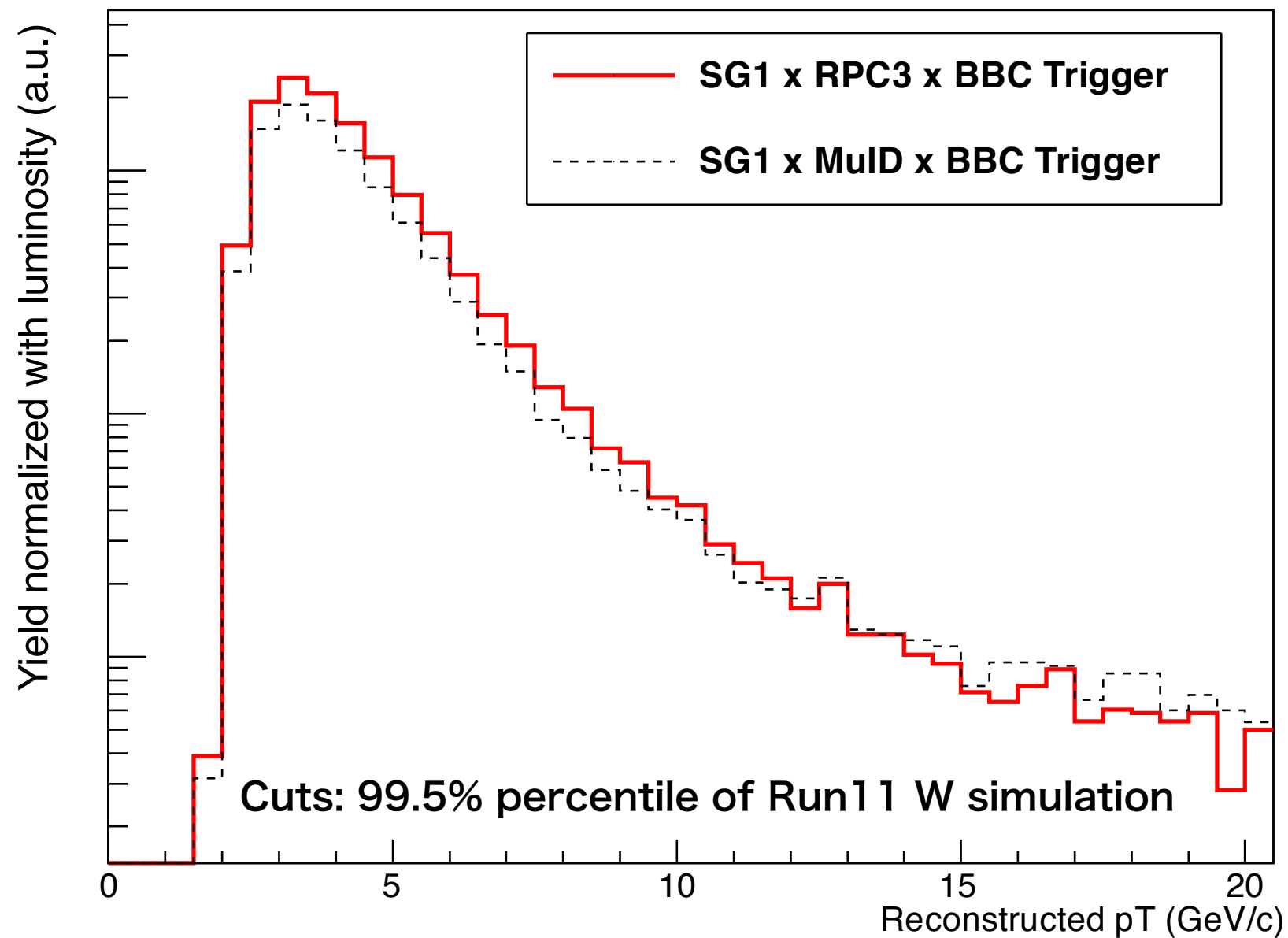
Run12 $W \rightarrow \mu$ trigger performance

SG1+RPC3 South

Basic cut w/ DCAr = 3 & RpcDCA = 10

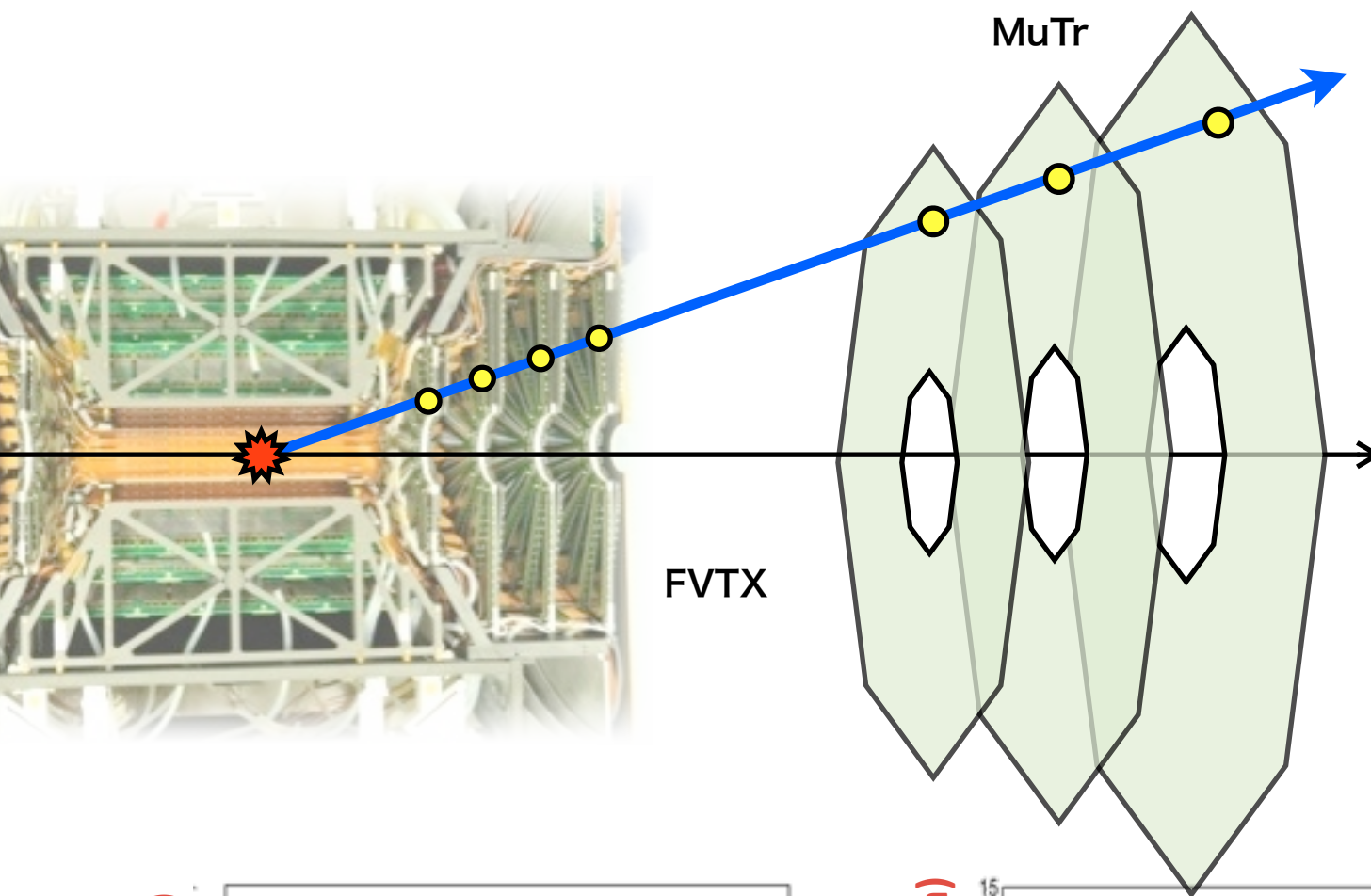


Run12 Trigger Performance



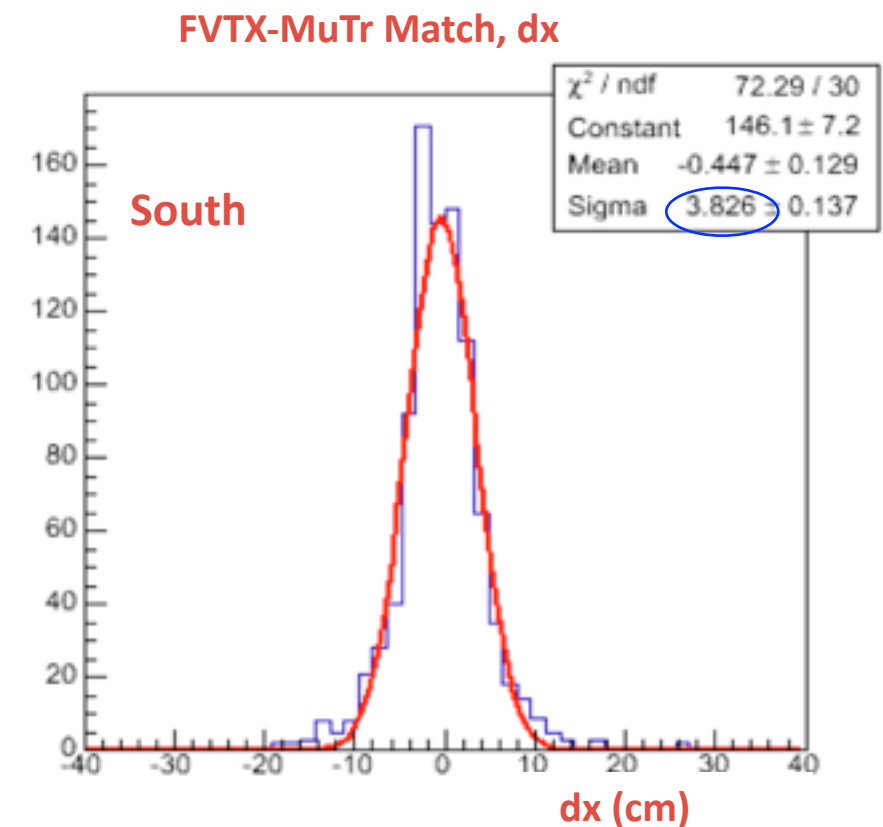
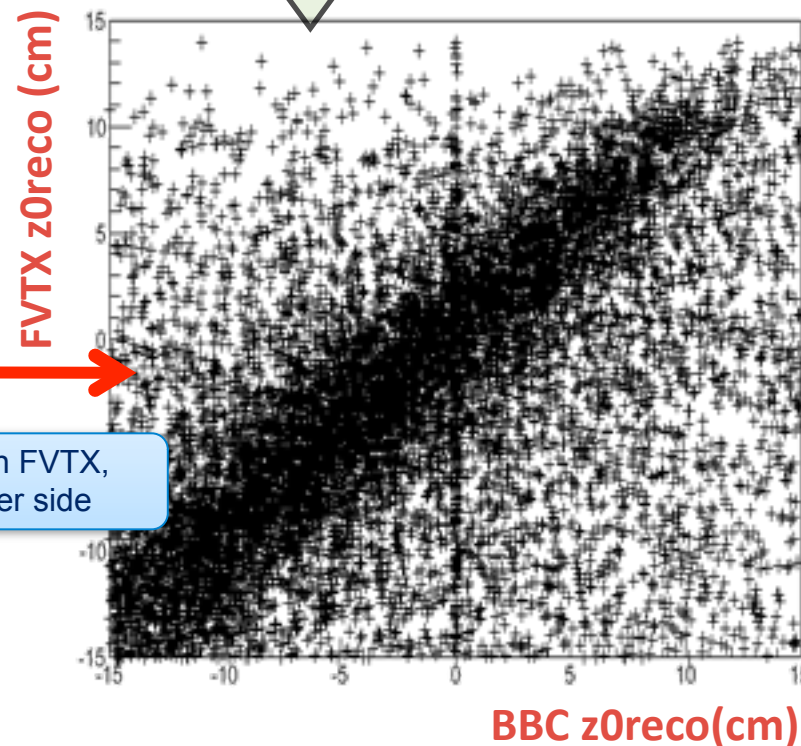
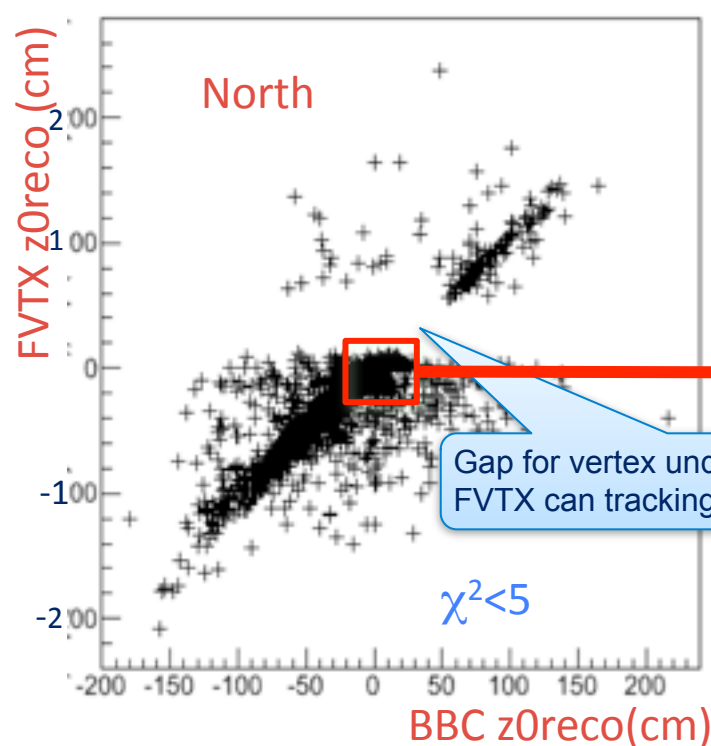
Run11 and Run12 triggers are consistent at fast quality check!

Operational of FVTX detector in Run12

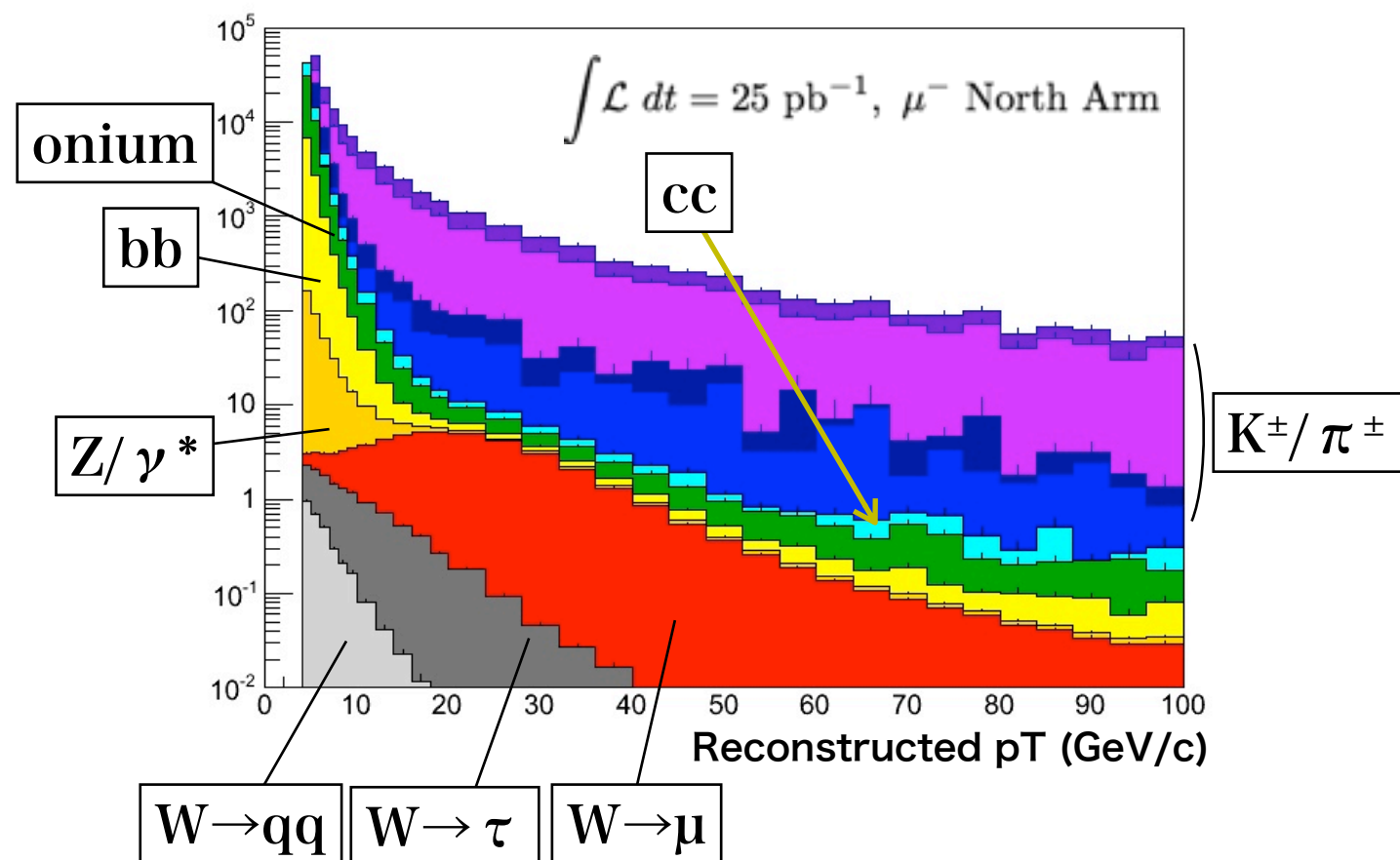
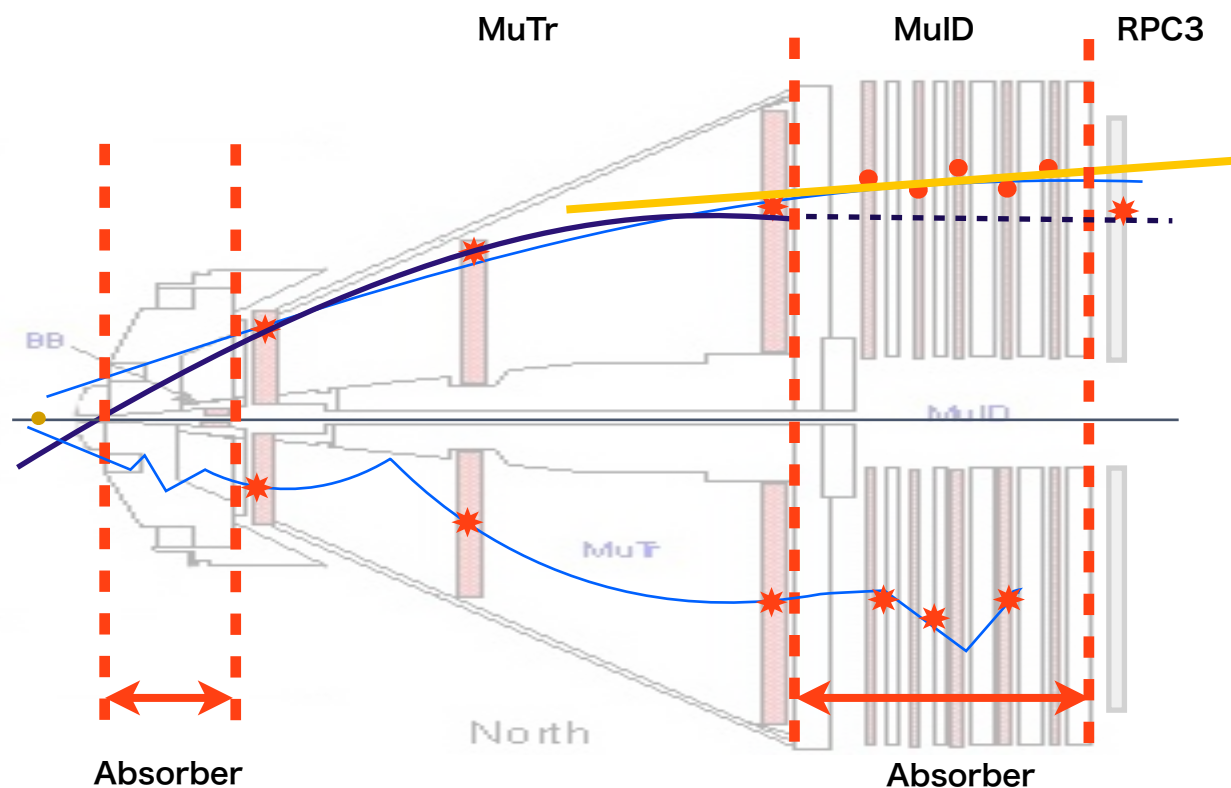


Expected to improve analysis power by

- Precise vertex determination
- Better Tracking



Run11 Forward Muon Analysis



Physics Trigger: SG1 x MuID x BBC

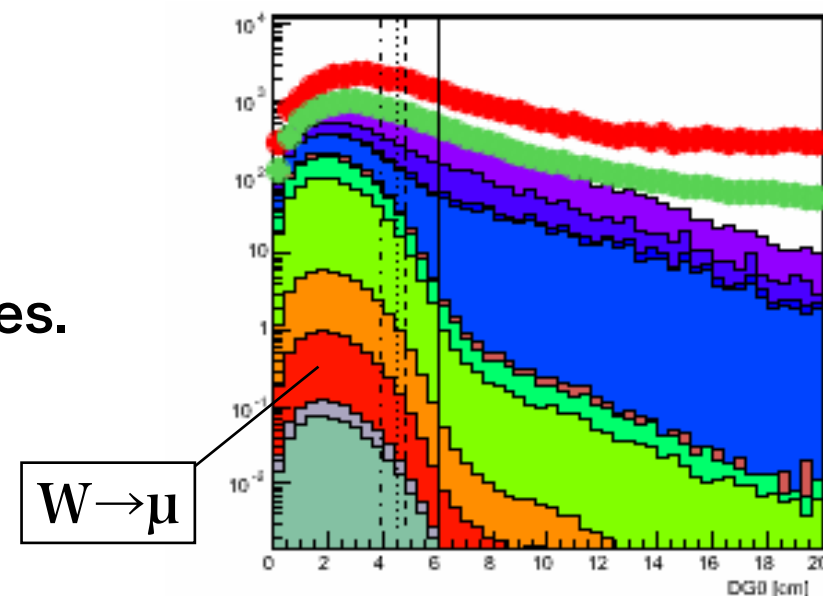
Backgrounds:

- Heavy flavor, onium (true muon)
- Fake high pT muons caused by hadrons

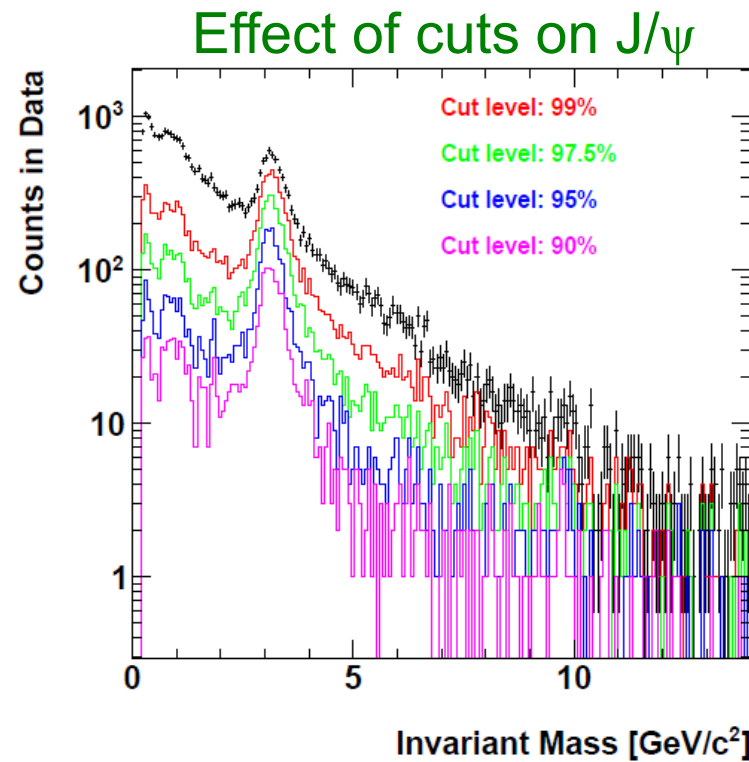
Tight kinematic cuts are applied to select true muon candidates.

- small multiple scattering : MuTr/MuID/RPC matching
- vertex requirement : Track/vertex(BBC) matching
- timing : RPC

MuTr/MuID matching (distance in cm)

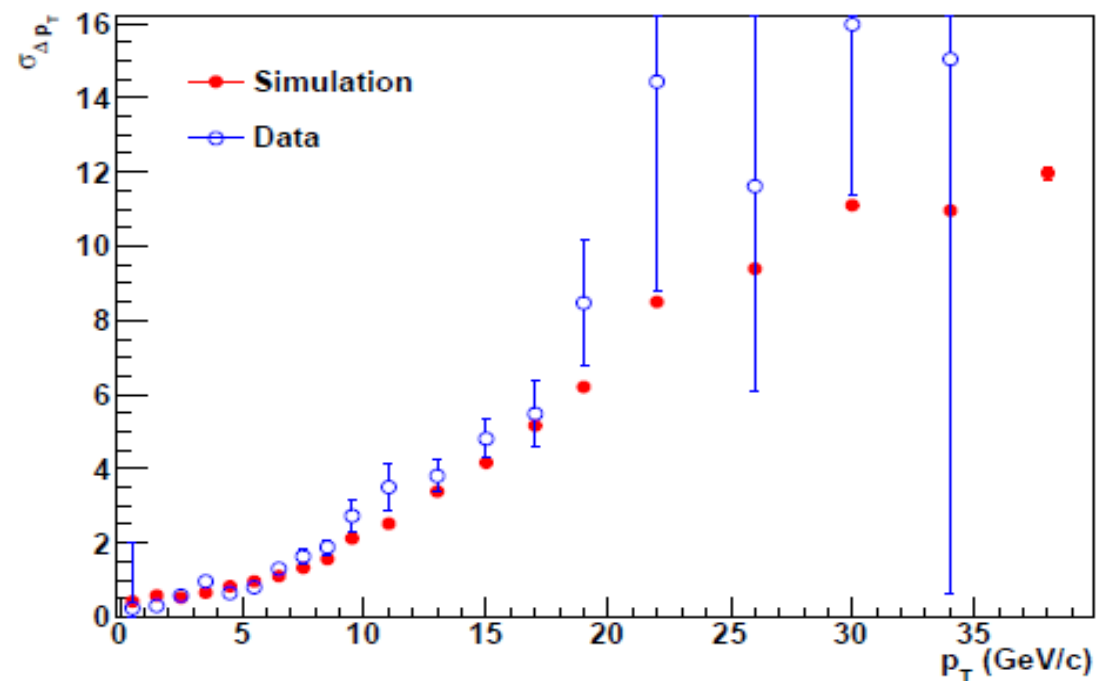


Validation of Cuts

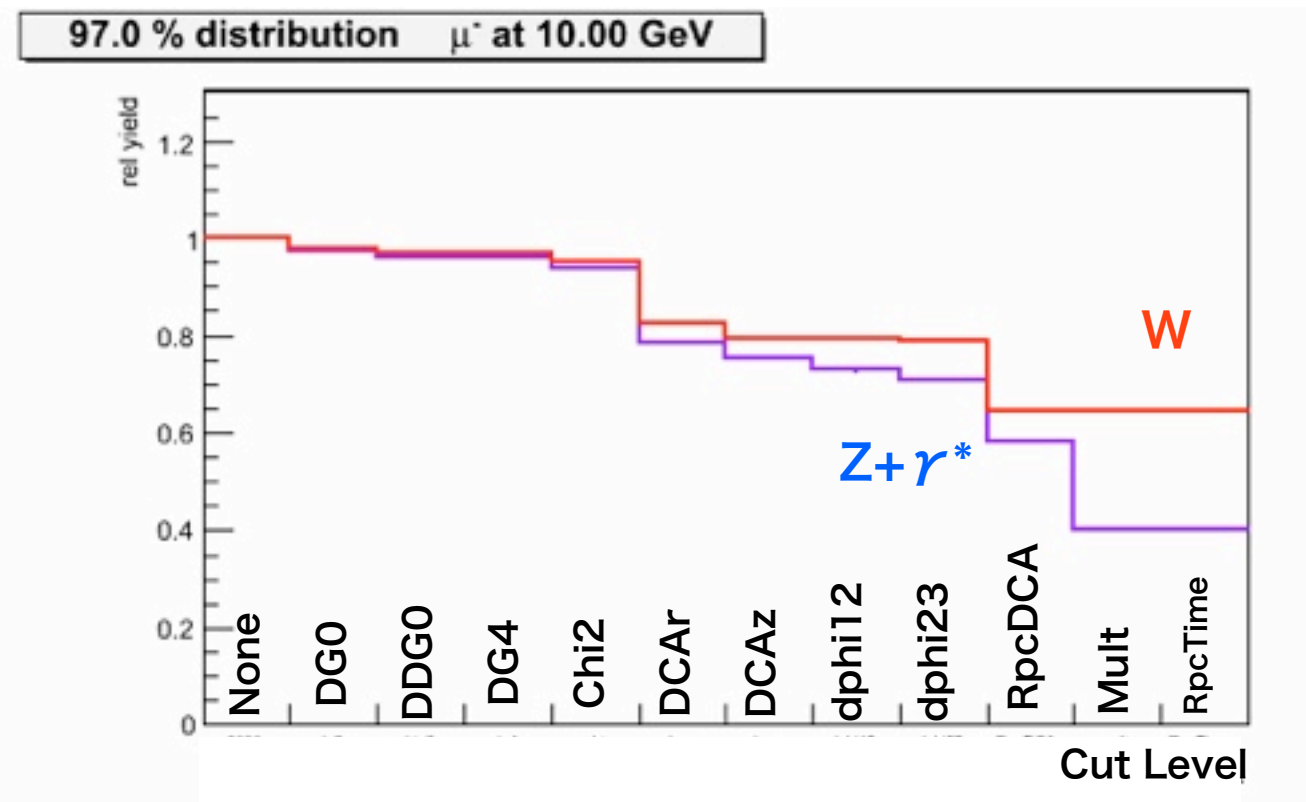


- Validation of cut positions with J/psi
- Smearing check with cosmic ray

Momentum resolution in cosmic ray

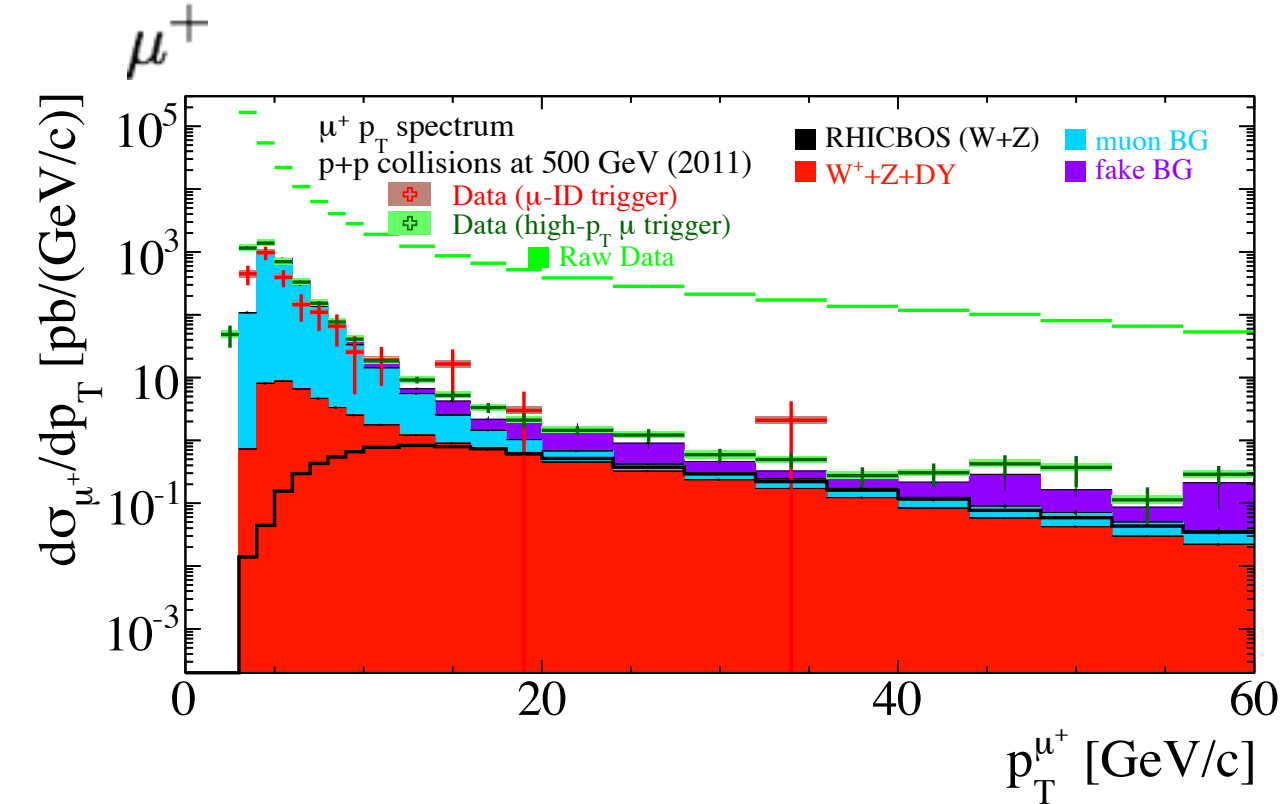


Cuts in simulation



Single Muon Spectrum

Single muon candidates cross section at tightest cut level



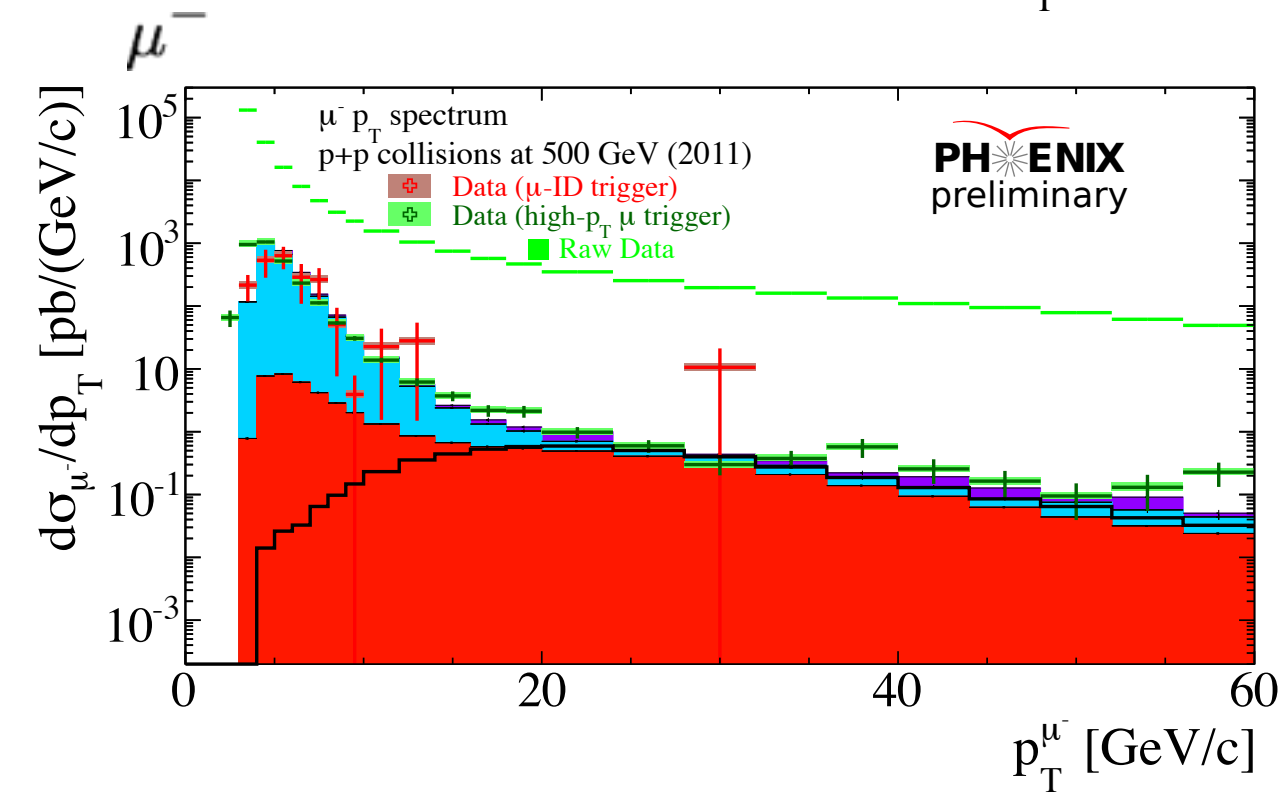
- Corrections:
- “SG1xMulDxBBC” trigger efficiency correction
 - Reconstruction x Acceptance correction
 - RPC efficiency correction
 - Luminosity correction

S/BG was extracted with assuming the W/Z cross section predicted by RHICBOS NLO calculation.

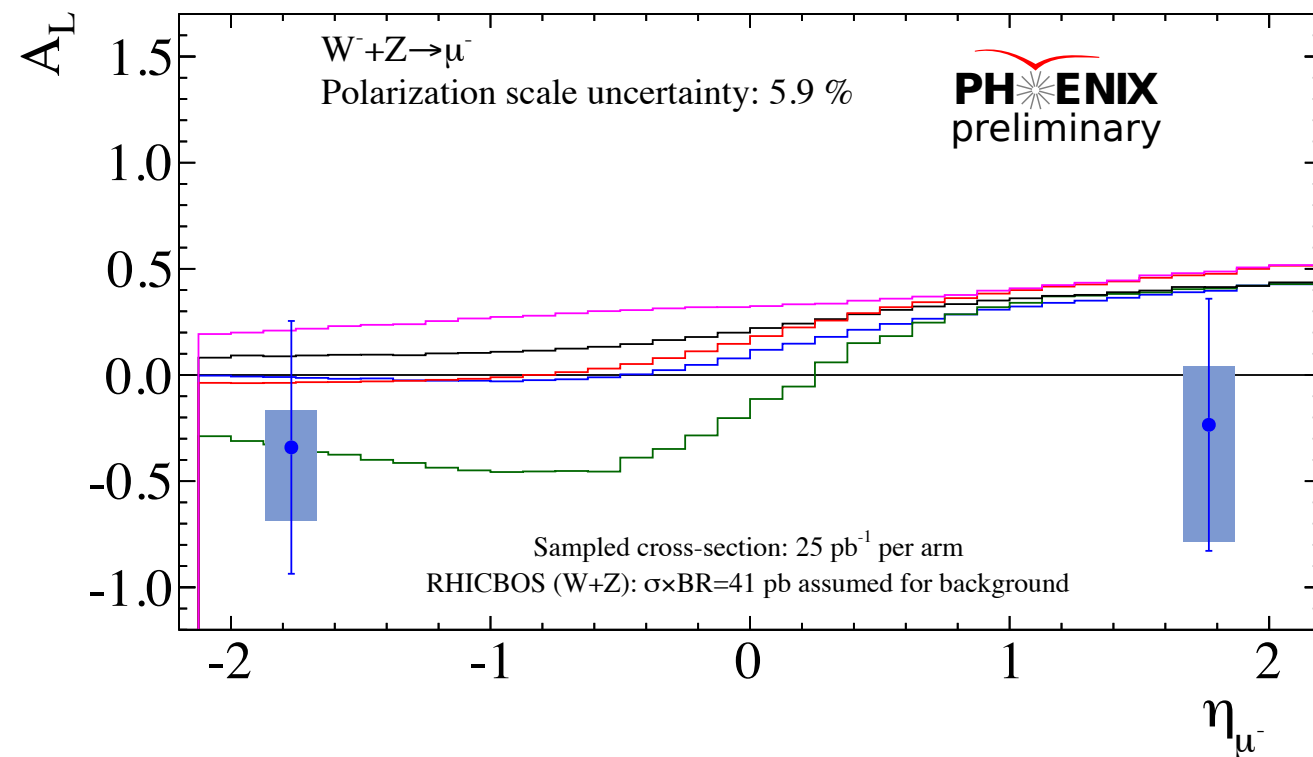
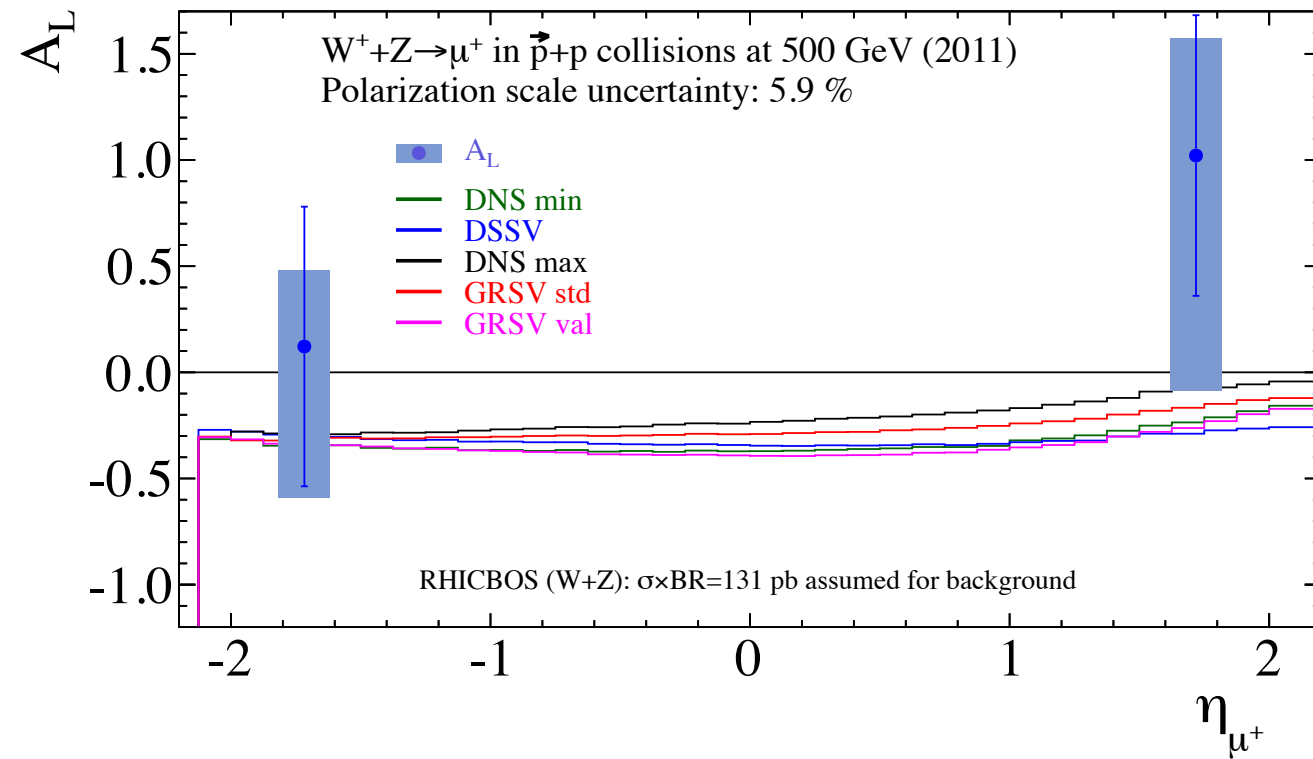
S/BG for muons in 18 - 60 GeV/c range with optimized statistical FOM:

S/BG	North	South
μ^+	0.21	0.40
μ^-	0.42	0.33

Factor [x0.5 - x2.0] range, as a conservative uncertainty of the S/BG



Run11 $W \rightarrow \mu$ single spin asymmetry (preliminary)



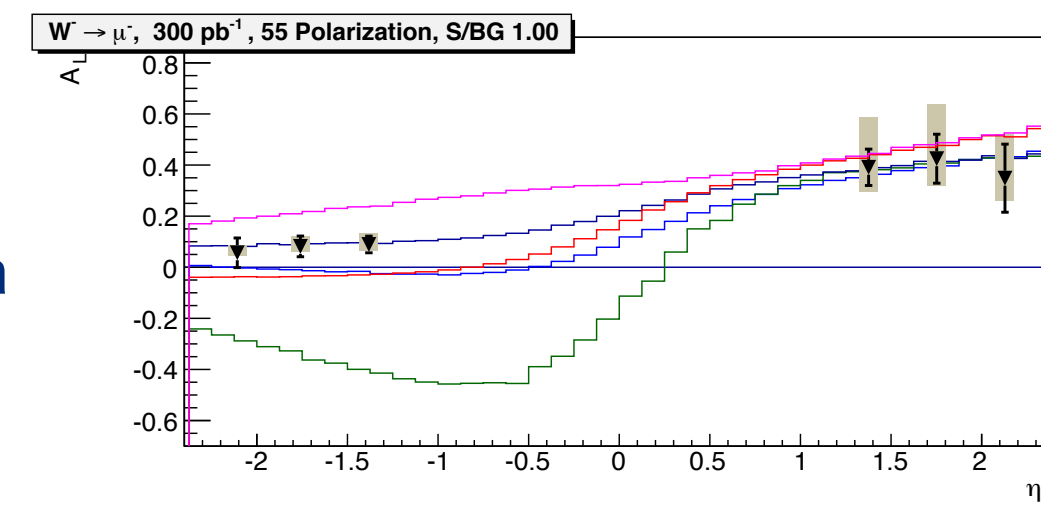
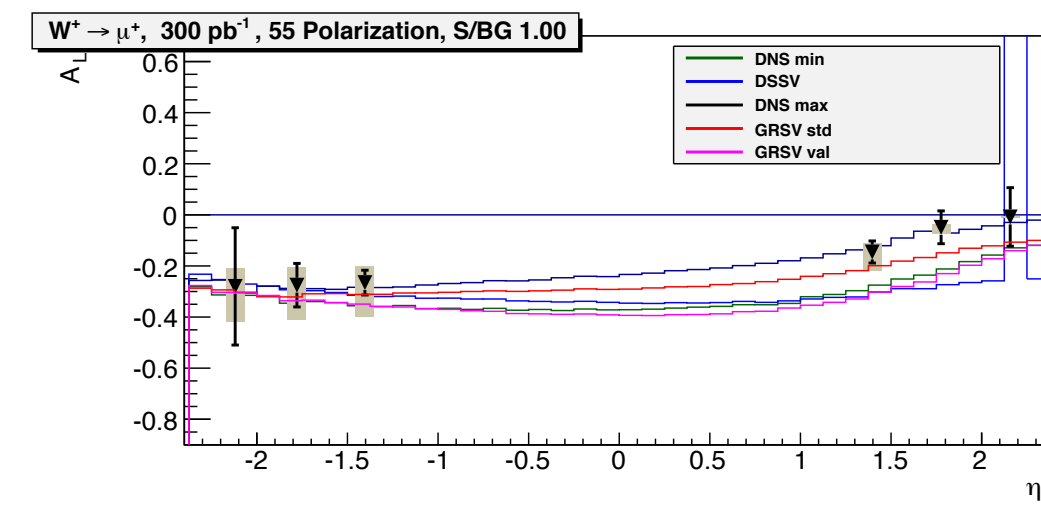
- $\sqrt{s} = 500 \text{ GeV}$
- Luminosity: $\sim 25 \text{ pb}^{-1}$
- Pol. : $\sim 50\%$

First forward W asymmetry result

Summary

- Run11 W analyses are in progress, stay tuned for coming results.
 - Update of central arm $W \rightarrow e$ since Run9 : coming soon.
 - The first forward arm $W \rightarrow \mu$: preliminary asymmetry result.
- Run12 $\sqrt{s} = 510$ GeV run ended successfully.
 - Operation of new muon trigger with RPC3.
 - Taking data with VTX, FVTX, and RPC1.
- In Run13, an integrated luminosity of 250 pb^{-1} in $|\text{vtx}| < 30 \text{ cm}$ is anticipated with full upgraded hardware set ready.

Expected single spin asymmetry in $W \rightarrow \mu$ at 300 pb^{-1}



Year		2011	2012	2013
Luminosity (pb^{-1})	$ \text{vtx} < 30 \text{ cm}$	~16	30	250?
	Full vtx	25	49	350?